

# Live Virtual Machine Migration Techniques in Cloud Computing: A Survey

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## ABSTRACT

Cloud computing is a service where storage and computing resources accessed on subscription basis. Cloud computing is powered by virtualization technology. Live migration is the process of moving a running virtual machine or an application between different physical machines without disconnecting the client, memory, network connectivity and storage of the virtual machine are transferred from the original host machine to the destination. This capability is being increasingly utilized in today's enterprise environments to provide efficient online system maintenance, reconfiguration, load balancing and fault tolerance. This paper presents a detailed survey on Live Migration of Virtual machines (VM) in cloud computing.

## Keywords

Cloud computing, Virtualization, Virtual machine, Live migration, Pre-copy, Post-copy.

## 1. INTRODUCTION

Virtualization, a technique to run several operating systems simultaneously on one physical server, has become a core concept in modern data centers, mainly driven by benefit of application isolation, resource sharing, fault tolerance, portability and cost efficiency. A special middleware, hypervisor, abstracts from physical hardware resources and provides so called virtual machines acting like real computers with their own (virtual) hardware resources. Live migration describes the process of copying a VM from one physical machine to another physical machine, while the VM is still powered on. It provides special benefit to server virtualization and has become a powerful tool for a variety of scenarios. Some of these include[2]:

**Power management:** The aim is to consolidate virtual machines through live migration on an optimal number of servers and selectively switch off underutilized servers to reduce data centers power consumption.

**IT maintenance:** Administrators can transparently move virtual machines to free and shut down hosts for maintenance purpose.

**Load balancing:** The aim is to adjust virtual machine placement to achieve critical business goals, such as high throughput and high availability.

Although live migration is widely used, it does not come along without any negative impact, causes performance loss of processes running inside VM as well as energy overheads.

The rest of this paper is organized as follows. Section 2 explains the different categories of migration, Section 3 introduces a

brief survey of migration techniques. Section 4 introduces taxonomy for migration performance metrics. Section 5 introduces the two major approaches, namely Post-copy and Pre-Copy. Section 6 introduces open issues and research challenges. The paper concludes with a summary of live virtual machine migration techniques.

## 2. DIFFERENT CATEGORIES OF MIGRATION TECHNIQUES

Live Virtual machine Migration is a technique that migrates the entire OS and its associated application from one physical machine to another. The Virtual machines are migrated live without disrupting the application running on it. The benefits of virtual machine migration include conservation of physical server energy, load balancing among the physical servers and failure tolerance in case of sudden failure. The different virtual machine migration techniques are as follows[7].

### 2.1 Fault Tolerant Migration Techniques

Fault tolerance allows the virtual machines to continue its job even any part of system fails. This technique migrates the virtual machine from one physical server to another physical server based upon the prediction of the failure occurred, fault tolerant migration technique is to improve the availability of physical server and avoids performance degradation of applications.

### 2.2 Load Balancing Migration Techniques

The Load balancing migration technique aims to distribute load across the physical servers to improve the scalability of physical servers in cloud environment. The Load balancing aids in minimizing the resource consumption, implementation of fail-over, enhancing scalability, avoiding bottlenecks and over provisioning of resources etc.

### 2.3 Energy Efficient Migration Techniques

The power consumption of Data center is mainly based on the utilization of the servers and their cooling systems. The servers typically need up to 70 percentage of their maximum power consumption even at their low utilization level. Therefore, there is a need for migration techniques that conserves the energy of servers by optimum resource utilization.

## 3. BACKGROUND

Virtualization provides facility to migrate virtual machine from one host (source) to another physical host (destination). Virtual Machine Migration (VMM) is a useful tool for administrator of data center and clusters, It allows clean separation between hardware and software. Process level migration problems can be

avoided by migrating a virtual machine. Virtual Machine Migration enables energy saving, load balancing and efficient resources utilization.

Virtual Machine Migration methods are divided into two types: Hot (live) migration and cold (non-live) migration. Virtual machine keeps running while migrating and does not lose its status. User doesn't feel any interruption in service in hot (live) migration. The status of the VM loses and user can notice the service interruption in cold migration. In live migration process, the state of a virtual machine to migrate is transferred. The state consists of its memory contents and local file system. Local file system need not be transferred. First, VM is suspended, then its state is transferred, and lastly, VM is resumed at destination host.

Sapuntzakis et. al. [13] presented how to quickly move the state of a running computer in the network, including the disks state, CPU registers, memory. It is a hardware state called a capsule and contain the entire operating system and running processes. They have introduced techniques to reduce the amount of data sent to the network. The copy on write disks track only the updates to capsule disks, unused memory and demand paging fetches needed blocks only and hashing avoids sending blocks exist at the remote end.

The basic idea of live migration algorithm was first proposed by Clark et. al. [14]. First Hypervisor marks all pages as dirty, then algorithm iteratively transfer dirty pages across the network until the number of pages remaining to be transferred is below a certain threshold or a maximum number of iterations is reached. Then Hypervisor mark transferred pages as clean, Since VM operates during live migration, So already transferred memory pages may be dirtied during iteration and must need to be re-transferred. The VM is suspended at some point on the source for stopping further memory writes and transfer remaining pages. After transferring all the memory contents, the VM resumes at destination server.

Nelson et. al. [15] describes the design and implementation of a system that uses virtual machine technology to provide fast, transparent application migration, neither the applications nor the operating systems need to be modified. Performance is measured with hundred virtual machines, migrating concurrently with standard industry benchmarks. It shows that for a variety of workloads, application downtime due to migration is less than a second.

A high performance VM migration design based on Remote Direct Memory Access was proposed by Huang et al. [16]. InfiniBand is an emerging interconnects providing feature such as Operating System bypass and RDMA. Remote Direct Memory Access is a direct memory access from the memory of one computer to that of another computer without involving their operating system. With the help of Remote Direct Memory Access remote memory can be read and write directly.

Luo et. al. [17] introduced a whole-system live migration technique, which transfers the whole system run time state, including CPU state, local disk storage, and memory data of the virtual machine. They proposed a three phase migration algorithm as well as an incremental migration algorithm, which migrate the virtual machine back to the source machine in a very short total migration time.

Bradford et. al. [18] presented a system for supporting the transparent, live wide-area migration of virtual machines which used local storage for their persistent state. This approach is transparent to the migrated VM, and does not interrupt open network connections to and from the VM during wide area

migration, This guarantees consistency of the VM's local persistent state at the source and the destination after migration, and is able to handle highly write intensive workloads.

#### **4. PERFORMANCE METRICS**

The performance of any live VM migration strategy could be gauged by the following metrics [5]

**(1)Preparation Time:**This is the time between initiating migration process and transferring the VMs processor state to the target node, during which the VM continues to execute and dirty its memory.

**(2) Down Time:**This is time during VMs execution is stopped. It includes the transfer of processor state..

**(3) Pages Transferred:**This is the total amount of memory pages transferred, including duplicates, across all of the above time periods.

**(4)Resume Time:**This is the time between resuming the VMs execution at the target and the end of migration, all dependencies on the source are eliminated.

**(5)Total Migration Time:**Total time taken by migration process from start migration process to finish the migration process. Total time is very important because of it affects the release of resources on both source and destination nodes.

**(6)Application Degradation:**When Virtual machine migrated from one host to another, the application performance is degraded which is running on that vm.

#### **5. LIVE VM MIGRATION IN CLOUD**

Live migration is an extremely powerful tool for cluster and cloud administrator. An administrator can migrate OS instances with application so that the machine can be freed for maintenance. Similarly, to improve manageability, OS instances may be rearranged across machines to relieve the load on overloaded hosts. To perform the live migration of a VM, its runtime state must be transferred from the source to the destination while VM still running.

There are two major approaches: Post-Copy and Pre-Copy memory migration[1]. In the Post-copy approach first suspends the migrating Virtual Machine at the source side then after copies minimal processor state to the target host and resumes the virtual machine, and begins fetching memory pages over the network from the source node.

There are two phases in Pre-copy approach: Warm-up phase and Stop-and-Copy phase. In warm up VM memory migration phase, the hypervisor copies all the memory pages from source to destination while the VM is still running on the source. If some memory pages change during memory copy process dirty pages, they will be re-copied until the rate of recopied pages is not less than page dirtying rate. In Stop and Copy phase, the VM will be stopped in source and the remaining dirty pages will be copied to the destination and VM will be resumed in destination.

Pre-Copy Phase: At this stage, the VM continues to run, while its memory is iteratively copied pagewise from the source to the target host. Iteratively means, the algorithm works in several rounds. It starts with transferring all active memory pages. As each round takes some time and in the mean time the VM is still running on the source host, some pages may be dirtied and have to be resent in an additional round to ensure memory consistency.

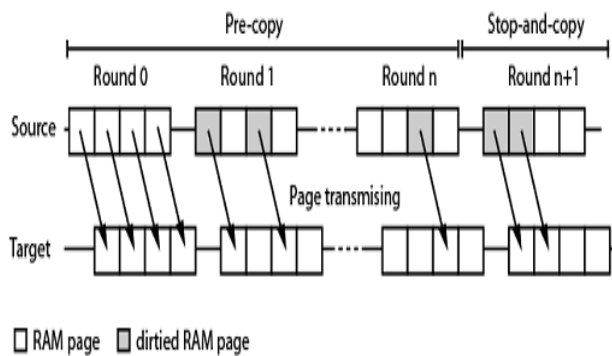


Fig. 1. Live Migration algorithm performs memory transfer [2]

**Pre-Copy Termination Phase:** Without any stop condition, the iteratively pre-copy phase may carry on indefinitely. Stop conditions depend highly on the design of the used hypervisor, but typically take one of the following thresholds into account: the number of performed iterations exceeds a pre-defined threshold, the total amount of memory that has already been transmitted, exceeds a pre-defined threshold.

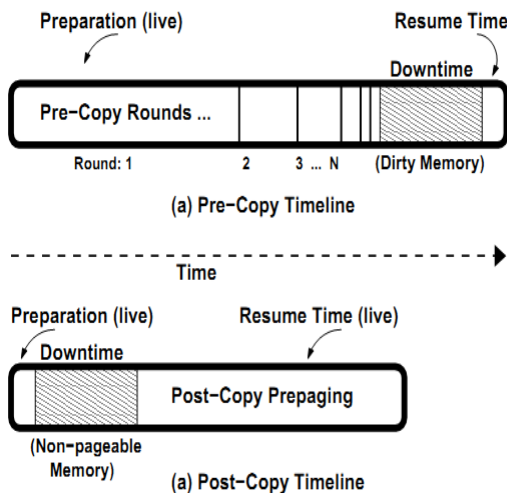


Fig. 2. Timeline for Pre-copy and Post-copy [5]

### Stop-and-Copy Phase

At this stage the hypervisor suspends the VM to stop page dirtying and copies the remaining dirty pages as well as the state of the CPU registers to the destination host. After the migration process is completed, the hypervisor on the target host resumes the VM.

## 6. OPEN ISSUES AND RESEARCH CHALLENGES

We have presented an evaluation of different techniques used for Virtual Machine migration. The entire set of migration parameters that may have an influence on the calculated migration cost value. Instead, the approaches concentrate on one, two or at maximum three parameters and adjust their validation environment accordingly. Hence there is no general model to estimate performance of migration, performance loss of virtual machine during migration and energy overhead for real world scenarios. Also Security is an important concern

when virtual machines are migrated from source machine to destination machine.

## 7. CONCLUSION AND FUTURE WORK

In this paper the previous approaches are introduced in terms of evolution of virtual machine live migration technique. Current approach for live migration, the pre-copy paradigm are explained. There are many techniques which attempt to minimize the down time and provide better performance in low bandwidth environment. We have categorized the papers and there is a need to compare techniques in each category to understand the strengths and weaknesses. In future, we plan to propose a performance model based on the research gaps identified through the limitations. This will be helpful for reducing the migration time with heavy workload.

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